The `lttemplates.dtx` code*

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1 Introduction

There are three broad "layers" between putting down ideas into a source file and ending up with a typeset document. These layers of document writing are

1. authoring of the text with mark-up;
2. document layout design;
3. implementation (with TeX programming) of the design.

We write the text as an author, and we see the visual output of the design after the document is generated; the TeX implementation in the middle is the glue between the two.

LaTeX's greatest success has been to standardise a system of mark-up that balances the trade-off between ease of reading and ease of writing to suit almost all forms of technical writing. It's other original strength was a good background in typographical design; while the standard LaTeX 2_ε classes look somewhat dated now in terms of their visual design, their typography is generally sound (barring the occasional minor faults).

However, LaTeX 2_ε has always lacked a standard approach to customising the visual design of a document. Changing the looks of the standard classes involved either:

- Creating a new version of the implementation code of the class and editing it.
- Loading one of the many packages to customise certain elements of the standard classes.
- Loading a completely different document class, such as KOMA-Script or memoir, that allows easy customization.

All three of these approaches have their drawbacks and learning curves.

The idea behind lttemplates is to cleanly separate the three layers introduced at the beginning of this section, so that document authors who are not programmers can easily change the design of their documents. lttemplates also makes it easier for LaTeX programmers to provide their own customizations on top of a pre-existing class.

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2 What is a document?

Besides the textual content of the words themselves, the source file of a document contains mark-up elements that add structure to the document. These elements include sectional divisions, figure/table captions, lists of various sorts, theorems/proofs, and so on. The list will be different for every document that can be written.

Each element can be represented logically without worrying about the formatting, with mark-up such as `\section`, `\caption`, `\begin{enumerate}` and so on. The output of each one of these document elements will be a typeset representation of the information marked up, and the visual arrangement and design of these elements can vary widely in producing a variety of desired outcomes.

For each type of document element, there may be design variations that contain the same sort of information but present it in slightly different ways. For example, the difference between a numbered and an unnumbered section, `\section` and `\section*`, or the difference between an itemized list or an enumerated list.

There are three distinct layers in the definition of "a document" at this level

1. semantic elements such as the ideas of sections and lists;
2. a set of design solutions for representing these elements visually;
3. specific variations for these designs that represent the elements in the document.

In the parlance of the template system, these are called types, templates, and instances, and they are discussed below in sections 4, 5, and 7, respectively.

3 Types, templates, and instances

By formally declaring documents to be composed of mark-up elements grouped into types, which are interpreted and typeset with a set of templates, each of which has one or more instances with which to compose each and every semantic unit of the text, we can cleanly separate the components of document construction.

All of the structures provided by the template system are global, and do not respect TEX grouping.

4 Template types

An *template type* (sometimes just "type") is an abstract idea of a document element that takes a fixed number of arguments corresponding to the information from the document author that it is representing. A sectioning type, for example, might take three inputs: "title", "short title", and "label".

Any given document class will define which types are to be used in the document, and any template of a given type can be used to generate an instance for the type. (Of course, different templates will produce different typeset representations, but the underlying content will be the same.)

\NewTemplateType `\NewTemplateType {⟨template type⟩} {⟨no. of args⟩}`

This function defines an ⟨*template type*⟩ taking ⟨*number of arguments*⟩, where the ⟨*type*⟩ is an abstraction as discussed above. For example,

```
\NewTemplateType{sectioning}{3}
```

creates a type "sectioning", where each use of that type will need three arguments.

5 Templates

A *template* is a generalized design solution for representing the information of a specified type. Templates that do the same thing, but in different ways, are grouped together by their type and given separate names. There are two important parts to a template:

- the parameters it takes to vary the design it is producing;
- the implementation of the design.

As a document author or designer does not care about the implementation but rather only the interface to the template, these two aspects of the template definition are split into two independent declarations, `\DeclareTemplateInterface` and `\DeclareTemplateCode`.

\DeclareTemplateInterface `\DeclareTemplateInterface {⟨type⟩} {⟨template⟩} {⟨no. of args⟩} {⟨key list⟩}`

A ⟨*template*⟩ interface is declared for a particular ⟨*type*⟩, where the ⟨*number of arguments*⟩ must agree with the type declaration. The interface itself is defined by the ⟨*key list*⟩, which is itself a key–value list taking a specialized format:

```
⟨key1⟩ : ⟨key type1⟩ ,
⟨key2⟩ : ⟨key type2⟩ ,
⟨key3⟩ : ⟨key type3⟩ = ⟨default3⟩ ,
⟨key4⟩ : ⟨key type4⟩ = ⟨default4⟩ ,
...
```

Each ⟨*key*⟩ name should consist of ASCII characters, with the exception of `,`, `=` and `:`. The recommended form for key names is to use lower case letters, with dashes to separate out different parts. Spaces are ignored in key names, so they can be included or missed out at will. Each ⟨*key*⟩ must have a ⟨*key type*⟩, which defines the type of input that the ⟨*key*⟩ requires. A full list of key types is given in Table 1. Each key may have a ⟨*default*⟩ value, which will be used in by the template if the ⟨*key*⟩ is not set explicitly. The ⟨*default*⟩ should be of the correct form to be accepted by the ⟨*key type*⟩ of the ⟨*key*⟩: this is not checked by the code. Expressions for numerical values are evaluated when the template is used, thus for example values given in terms of `em` or `ex` will be set respecting the prevailing font.

Key-type	Description of input
`boolean`	`true` or `false`
`choice{`⟨*choices*⟩`}`	A list of pre-defined ⟨*choices*⟩
`commalist`	A comma-separated list
`function{`⟨N⟩`}`	A function definition with N arguments (N from 0 to 9)
`instance{`⟨*name*⟩`}`	An instance of type ⟨*name*⟩
`integer`	An integer or integer expression
`length`	A fixed length
`muskip`	A math length with shrink and stretch components
`real`	A real (floating point) value
`skip`	A length with shrink and stretch components
`tokenlist`	A token list: any text or commands

Table 1: Key-types for defining template interfaces with `\DeclareTemplateInterface`.

`\KeyValue` `\KeyValue {`⟨*key name*⟩`}`

There are occasions where the default (or value) for one key should be taken from another. The `\KeyValue` function can be used to transfer this information without needing to know the internal implementation of the key:

```
\DeclareTemplateInterface { type } { template } { no. of args }
  {
    key-name-1 : key-type = value ,
    key-name-2 : key-type = \KeyValue { key-name-1 },
    ...
  }
```

Key-type	Description of binding
`boolean`	Boolean variable, *e.g.* `\l_tmpa_bool`
`choice`	List of choice implementations (see Section 6)
`commalist`	Comma list, *e.g.* `\l_tmpa_clist`
`function`	Function taking N arguments, *e.g.* `\use_i:nn`
`instance`	
`integer`	Integer variable, *e.g.* `\l_tmpa_int`
`length`	Dimension variable, *e.g.* `\l_tmpa_dim`
`muskip`	Muskip variable, *e.g.* `\l_tmpa_muskip`
`real`	Floating-point variable, *e.g.* `\l_tmpa_fp`
`skip`	Skip variable, *e.g.* `\l_tmpa_skip`
`tokenlist`	Token list variable, *e.g.* `\l_tmpa_tl`

Table 2: Bindings required for different key types when defining template implementations with `\DeclareTemplateCode`. Apart from `code`, `choice` and `function` all of these accept the key word `global` to carry out a global assignment.

`\DeclareTemplateCode`

```
\DeclareTemplateCode
  {⟨type⟩} {⟨template⟩} {⟨no. of args⟩}
  {⟨key bindings⟩} {⟨code⟩}
```

The relationship between a templates keys and the internal implementation is created using the `\DeclareTemplateCode` function. As with `\DeclareTemplateInterface`, the ⟨*template*⟩ name is given along with the ⟨*type*⟩ and ⟨*number of arguments*⟩ required. The ⟨*key bindings*⟩ argument is a key–value list which specifies the relationship between each ⟨*key*⟩ of the template interface with an underlying ⟨*variable*⟩.

```
⟨key1⟩ = ⟨variable1⟩,
⟨key2⟩ = ⟨variable2⟩,
⟨key3⟩ = global ⟨variable3⟩,
⟨key4⟩ = global ⟨variable4⟩,
...
```

With the exception of the choice, code and function key types, the ⟨*variable*⟩ here should be the name of an existing LaTeX3 register. As illustrated, the key word "global" may be included in the listing to indicate that the ⟨*variable*⟩ should be assigned globally. A full list of variable bindings is given in Table 2.

The ⟨*code*⟩ argument of `\DeclareTemplateCode` is used as the replacement text for the template when it is used, either directly or as an instance. This may therefore accept arguments `#1`, `#2`, *etc.* as detailed by the ⟨*number of arguments*⟩ taken by the type.

`\AssignTemplateKeys`

```
\AssignTemplateKeys
```

In the final argument of `\DeclareTemplateCode` the assignment of keys defined by the template may be delayed by including the command `\AssignTemplateKeys`. If this is *not* present, keys are assigned immediately before the template code. If an `\AssignTemplateKeys` command is present, assignment is delayed until this point. Note that the command must be *directly* present in the code, not placed within a nested command/macro.

\SetKnownTemplateKeys	\SetKnownTemplateKeys {⟨*type*⟩} {⟨*template*⟩} {⟨*keyvals*⟩}
\SetTemplateKeys	\SetTemplateKeys {⟨*type*⟩} {⟨*template*⟩} {⟨*keyvals*⟩}
\UnusedTemplateKeys	\UnusedTemplateKeys % all ⟨*keyvals*⟩ unused by previous \SetKnownTemplateKeys

In the final argument of `\DeclareTemplateCode` one can also overwrite (some of) the current template key value settings by using the command `\SetKnownTemplateKeys` or `\SetTemplateKeys`, i.e., they can overwrite the template default values and the values assigned by the instance.

The `\SetKnownTemplateKeys` and `\SetTemplateKeys` commands are only supported within the code of a template; using them elsewhere has unpredictable results. If they are used together with `\AssignTemplateKeys` then the latter command should come first in the template code.

The main use case for these commands is the situation where there is an argument (normally `#1`) to the template in which a key/value list can be specified that overwrites the normal settings. In that case one could use

`\SetKnownTemplateKeys{`⟨*type*⟩`}{`⟨*template*⟩`}{#1}`

to process this key/value list inside the template.

If `\SetKnownTemplateKeys` is executed and the ⟨*keyvals*⟩ argument contains keys not known to the ⟨*template*⟩ they are simply ignored and stored in the tokenlist `\UnusedTemplateKeys` without generating an error. This way it is possible to apply the same key/val list specified by the user on a document-level command or environment to several templates, which is useful, if the command or environment is implemented by calling several different template instances.

As a variation of that, you can use this key/val list the first time, and for the next template instance use what remains in `\UnusedTemplateKeys` (i.e., the key/val list with only the keys that have not been processed previously). The final processing step could then be `\SetTemplateKeys`, which unconditionally attempts to set the ⟨*keyvals*⟩ received in its third argument. This command complains if any of them are unknown keys. Alternatively, you could use `\SetKnownTemplateKeys` and afterwards check whether `\UnusedTemplateKeys` is empty.[1]

For example, a list, such as `enumerate`, is made up from a `blockenv`, `block`, `list`, and a `para` template and in the single user-supplied optional argument of `enumerate` key/values for any of these templates might be specified.

In fact, in the particular example of list environments, the supplied key/value list is also saved and then applied to each `\item` which is implemented through an `item` template. This way, one can specify one-off settings for all the items of a single list (on the environment level), as well as to individual items within that list (by specifying them in the optional argument of an `\item`). With `\SetKnownTemplateKeys` and `\SetTemplateKeys` working together, it is possible to provide this flexibility and still alert the user when one of their keys is misspelled.

On the other hand you may want to allow for "misspellings" without generating an error or a warning. For example, if you define a template that accepts only a few keys, you might just want to ignore anything specified in the source when you use this template in place of a different one, without the need to alter the document source. Or you might

[1] Using `\SetTemplateKeys` exposes the inner structure of the template keys when generating an error. This is something one may want to avoid as it can be confusing to the user, especially if several templates are involved. In that case use `\SetKnownTemplateKeys` and afterwards check whether `\UnusedTemplateKeys` is empty; if it is not empty then generate your own error message.

just generate a warning message, which is easy, given that the unused key/values are available in the `\UnusedTemplateKeys` variable.

`\DeclareTemplateCopy`

```
\DeclareTemplateCopy
  {⟨type⟩} {⟨template2⟩} {⟨template1⟩}
```

Copies ⟨*template1*⟩ of ⟨*type*⟩ to a new name ⟨*template2*⟩: the copy can then be edited independent of the original.

6 Multiple choices

The `choice` key type implements multiple choice input. At the interface level, only the list of valid choices is needed:

```
\DeclareTemplateInterface { foo } { bar } { 0 }
  { key-name : choice { A, B, C } }
```

where the choices are given as a comma-list (which must therefore be wrapped in braces). A default value can also be given:

```
\DeclareTemplateInterface { foo } { bar } { 0 }
  { key-name : choice { A, B, C } = A }
```

At the implementation level, each choice is associated with code, using a nested key–value list.

```
\DeclareTemplateCode { foo } { bar } { 0 }
  {
    key-name =
      {
        A = Code-A ,
        B = Code-B ,
        C = Code-C
      }
   }
   { ... }
```

The two choice lists should match, but in the implementation a special `unknown` choice is also available. This can be used to ignore values and implement an "else" branch:

```
\DeclareTemplateCode { foo } { bar } { 0 }
  {
    key-name =
      {
        A       = Code-A ,
        B       = Code-B ,
        C       = Code-C ,
        unknown = Else-code
      }
   }
   { ... }
```

The `unknown` entry must be the last one given, and should *not* be listed in the interface part of the template.

For keys which accept the values `true` and `false` both the boolean and choice key types can be used. As template interfaces are intended to prompt clarity at the design level, the boolean key type should be favored, with the choice type reserved for keys which take arbitrary values.

7 Instances

After a template is defined it still needs to be put to use. The parameters that it expects need to be defined before it can be used in a document. Every time a template has parameters given to it, an *instance* is created, and this is the code that ends up in the document to perform the typesetting of whatever pieces of information are input into it.

For example, a template might say "here is a section with or without a number that might be centered or left aligned and print its contents in a certain font of a certain size, with a bit of a gap before and after it" whereas an instance declares "this is a section with a number, which is centered and set in 12 pt italic with a 10 pt skip before and a 12 pt skip after it". Therefore, an instance is just a frozen version of a template with specific settings as chosen by the designer.

`\DeclareInstance`

```
\DeclareInstance
  {⟨type⟩} {⟨instance⟩} {⟨template⟩} {⟨parameters⟩}
```

This function uses a ⟨*template*⟩ for an ⟨*type*⟩ to create an ⟨*instance*⟩. The ⟨*instance*⟩ will be set up using the ⟨*parameters*⟩, which will set some of the ⟨*keys*⟩ in the ⟨*template*⟩.

As a practical example, consider a type for document sections (which might include chapters, parts, sections, *etc.*), which is called `sectioning`. One possible template for this type might be called `basic`, and one instance of this template would be a numbered section. The instance declaration might read:

```
\DeclareInstance { sectioning } { section-num } { basic }
  {
    numbered      = true ,
    justification = center ,
    font          =\normalsize\itshape ,
    before-skip   = 10pt ,
    after-skip    = 12pt ,
  }
```

Of course, the key names here are entirely imaginary, but illustrate the general idea of fixing some settings.

`\IfInstanceExistsT` `\IfInstanceExistsF` `\IfInstanceExistsTF`

```
\IfInstanceExistsTF {⟨type⟩} {⟨instance⟩} {⟨true code⟩} {⟨false code⟩}
```

Tests if the named ⟨*instance*⟩ of a ⟨*type*⟩ exists, and then inserts the appropriate code into the input stream.

`\DeclareInstanceCopy`

```
\DeclareInstanceCopy
  {⟨type⟩} {⟨instance2⟩} {⟨instance1⟩}
```

Copies the ⟨*values*⟩ for ⟨*instance1*⟩ for an ⟨*type*⟩ to ⟨*instance2*⟩.

8 Document interface

After the instances have been chosen, document commands must be declared to use those instances in the document. `\UseInstance` calls instances directly, and this command should be used internally in document-level mark-up.

`\UseInstance`

```
\UseInstance
  {⟨type⟩} {⟨instance⟩} ⟨arguments⟩
```

Uses an ⟨*instance*⟩ of the ⟨*type*⟩, which will require ⟨*arguments*⟩ as determined by the number specified for the ⟨*type*⟩. The ⟨*instance*⟩ must have been declared before it can be used, otherwise an error is raised.

`\UseTemplate`

```
\UseTemplate {⟨type⟩} {⟨template⟩}
  {⟨settings⟩} ⟨arguments⟩
```

Uses the ⟨*template*⟩ of the specified ⟨*type*⟩, applying the ⟨*settings*⟩ and absorbing ⟨*arguments*⟩ as detailed by the ⟨*type*⟩ declaration. This in effect is the same as creating an instance using `\DeclareInstance` and immediately using it with `\UseInstance`, but without the instance having any further existence. This command is therefore useful when a template needs to be used only once.

This function can also be used as the argument to `instance` key types:

```
\DeclareInstance { type } { template } { instance }
  {
    instance-key =
      \UseTemplate { type2 } { template2 } { <settings> }
  }
```

9 Changing existing definitions

Template parameters may be assigned specific defaults for instances to use if the instance declaration doesn't explicit set those parameters. In some cases, the document designer will wish to edit these defaults to allow them to "cascade" to the instances. The alternative would be to set each parameter identically for each instance declaration, a tedious and error-prone process.

`\EditTemplateDefaults`

```
\EditTemplateDefaults
  {⟨type⟩} {⟨template⟩} {⟨new defaults⟩}
```

Edits the ⟨*defaults*⟩ for a ⟨*template*⟩ for an ⟨*type*⟩. The ⟨*new defaults*⟩, given as a key–value list, replace the existing defaults for the ⟨*template*⟩. This means that the change will apply to instances declared after the editing, but that instances which have already been created are unaffected.

`\EditInstance`

```
\EditInstance
  {⟨type⟩} {⟨instance⟩} {⟨new values⟩}
```

Edits the ⟨*values*⟩ for an ⟨*instance*⟩ for an ⟨*type*⟩. The ⟨*new values*⟩, given as a key–value list, replace the existing values for the ⟨*instance*⟩. This function is complementary to `\EditTemplateDefaults`: `\EditInstance` changes a single instance while leaving the template untouched.

9.1 Expanding the values of keys

To allow the user to apply expansion of values when the key is set, key names can be followed by an expansion specifier. This is given by appending `:` and a single letter specifier to the key name. These letters are the normal argument specifiers for expl3, thus they may be one of `n` (redundant but supported), `o`, `V`, `v`, `e`, `N` (again redundant) or `c`. Expansion of a control sequence name is particularly useful when you need to refer to an internal LaTeX 2_ε or an L3 programming layer variable, e.g.,

```
key-a:c =  @itemdepth , % use \@itemdepth as the value
key-b:v =  @itemdepth   % use the current value of \@itempdepth as the value
```

10 Getting information about templates and instances

\ShowInstanceValues `\ShowInstanceValues {⟨type⟩} {⟨instance⟩}`

Shows the ⟨*values*⟩ for an ⟨*instance*⟩ of the given ⟨*type*⟩ at the terminal.

\ShowTemplateCode `\ShowTemplateCode {⟨type⟩} {⟨template⟩}`

Shows the ⟨*code*⟩ of a ⟨*template*⟩ for an ⟨*type*⟩ in the terminal.

\ShowTemplateDefaults `\ShowTemplateDefaults {⟨type⟩} {⟨template⟩}`

Shows the ⟨*default*⟩ values of a ⟨*template*⟩ for an ⟨*type*⟩ in the terminal.

\ShowTemplateInterface `\ShowTemplateInterface {⟨type⟩} {⟨template⟩}`

Shows the ⟨*keys*⟩ and associated ⟨*key types*⟩ of a ⟨*template*⟩ for an ⟨*type*⟩ in the terminal.

\ShowTemplateVariables `\ShowTemplateVariables {⟨type⟩} {⟨template⟩}`

Shows the ⟨*variables*⟩ and associated ⟨*keys*⟩ of a ⟨*template*⟩ for an ⟨*type*⟩ in the terminal. Note that `code` and `choice` keys do not map directly to variables but to arbitrary code. For `choice` keys, each valid choice is shown as a separate entry in the list, with the key name and choice separated by a space, for example

```
Template 'example' of type 'example' has variable mapping:
>  demo unknown  =>  \def \demo {?}
>  demo c  =>  \def \demo {c}
>  demo b  =>  \def \demo {b}
>  demo a  =>  \def \demo {a}.
```

would be shown for a choice key `demo` with valid choices `a`, `b` and `c`, plus code for an `unknown` branch.

11 The implementation

```
⟨@@=template⟩
⟨*2ekernel⟩
\message{templates,}
⟨/2ekernel⟩
⟨*2ekernel | latexrelease⟩
\ExplSyntaxOn
⟨latexrelease⟩\NewModuleRelease{2024/06/01}{lttemplates}
⟨latexrelease⟩                    {Prototype~document~commands}%
```

11.1 Variables and constants

```
\c__template_code_root_tl
\c__template_defaults_root_tl
\c__template_instances_root_tl
\c__template_keytypes_root_tl
\c__template_key_order_root_tl
\c__template_restrict_root_tl
\c__template_values_root_tl
\c__template_vars_root_tl
```

So that literal values are kept to a minimum.

```
\tl_const:Nn \c__template_code_root_tl      { template~code~>~ }
\tl_const:Nn \c__template_defaults_root_tl  { template~defaults~>~ }
\tl_const:Nn \c__template_instances_root_tl { template~instance~>~  }
\tl_const:Nn \c__template_keytypes_root_tl  { template~key~types~>~ }
\tl_const:Nn \c__template_key_order_root_tl { template~key~order~>~ }
\tl_const:Nn \c__template_values_root_tl    { template~values~>~ }
\tl_const:Nn \c__template_vars_root_tl      { template~vars~>~ }
```

```
\c__template_keytypes_arg_seq
```

A list of keytypes which also need additional data (an argument), used to parse the keytype correctly.

```
\seq_const_from_clist:Nn \c__template_keytypes_arg_seq
  { choice , function , instance }
```

`\g__template_type_prop` For storing types and the associated number of arguments.

```
\prop_new:N \g__template_type_prop
```

```
\l__template_assignments_tl
```

When creating an instance, the assigned values are collected here.

```
\tl_new:N \l__template_assignments_tl
```

`\l__template_default_tl` The default value for a key is recovered here from the property list in which it is stored.

```
\tl_new:N \l__template_default_tl
```

`\l__template_error_bool` A flag for errors to be carried forward.

```
\bool_new:N \l__template_error_bool
```

`\l__template_global_bool` Used to indicate that assignments should be global.

```
\bool_new:N \l__template_global_bool
```

`\l__template_key_name_tl`
`\l__template_keytype_tl`
`\l__template_keytype_arg_tl`
`\l__template_value_tl`
`\l__template_var_tl`

When defining each key in a template, the name and type of the key need to be separated and stored. Any argument needed by the keytype is also stored separately.

```
\tl_new:N \l__template_key_name_tl
\tl_new:N \l__template_keytype_tl
\tl_new:N \l__template_keytype_arg_tl
\tl_new:N \l__template_value_tl
\tl_new:N \l__template_var_tl
```

`\l__template_value_exp_str`

```
\str_new:N \l__template_value_exp_str
```

`\l__template_keytypes_prop`
`\l__template_key_order_seq`
`\l__template_values_prop`
`\l__template_vars_prop`

To avoid needing too many difficult-to-follow csname assignments, various scratch token registers are used to build up data, which is then transferred

```
\prop_new:N \l__template_keytypes_prop
\seq_new:N \l__template_key_order_seq
\prop_new:N \l__template_values_prop
\prop_new:N \l__template_vars_prop
```

`\l__template_tmp_clist`
`\l__template_tmp_dim`
`\l__template_tmp_int`
`\l__template_tmp_muskip`
`\l__template_tmp_skip`
`\l__template_tmp_tl`

Scratch space.

```
\clist_new:N \l__template_tmp_clist
\dim_new:N \l__template_tmp_dim
\int_new:N \l__template_tmp_int
\muskip_new:N \l__template_tmp_muskip
\skip_new:N \l__template_tmp_skip
\tl_new:N \l__template_tmp_tl
```

`\s__template_mark` Internal scan marks.
`\s__template_stop`

```
\scan_new:N \s__template_mark
\scan_new:N \s__template_stop
```

\q__template_nil Internal quarks.

```
\quark_new:N \q__template_nil
```

__template_quark_if_nil_p:n Branching quark conditional.
__template_quark_if_nil:nTF

```
\__kernel_quark_new_conditional:Nn \__template_quark_if_nil:N { F }
```

(*End of definition for* __template_quark_if_nil:nTF.)

11.2 Testing existence and validity

There are a number of checks needed for either the existence of a type, template or instance. There are also some for the validity of a particular call. All of these are collected up here.

__template_execute_if_arg_agree:nnT A test agreement between the number of arguments for the template type and that specified when creating a template. This is not done as a separate conditional for efficiency and better error message

```
\cs_new_protected:Npn \__template_execute_if_arg_agree:nnT #1#2#3
  {
    \prop_get:NnN \g__template_type_prop {#1} \l__template_tmp_tl
    \int_compare:nNnTF {#2} = \l__template_tmp_tl
       {#3}
       {
         \msg_error:nneee { template } { argument-number-mismatch }
           {#1} { \l__template_tmp_tl } {#2}
       }
  }
```

(*End of definition for* __template_execute_if_arg_agree:nnT.)

__template_execute_if_code_exist:nnT A template is only fully declared if the code has been set up, which can be checked by looking for the template function itself.

```
\cs_new_protected:Npn \__template_execute_if_code_exist:nnT #1#2#3
  {
    \cs_if_exist:cTF { \c__template_code_root_tl #1 / #2 }
      {#3}
      { \msg_error:nnnn { template } { no-template-code } {#1} {#2} }
  }
```

(*End of definition for* __template_execute_if_code_exist:nnT.)

__template_execute_if_keytype_exist:nT The test for valid keytypes looks for a function to set up the key, which is part of the
__template_execute_if_keytype_exist:VT "code" side of the template definition. This avoids having different lists for the two parts of the process.

```
\cs_new_protected:Npn \__template_execute_if_keytype_exist:nT #1#2
  {
    \cs_if_exist:cTF { __template_store_value_ #1 :n }
      {#2}
      { \msg_error:nnn { template } { unknown-keytype } {#1} }
  }
\cs_generate_variant:Nn \__template_execute_if_keytype_exist:nT { V }
```

(*End of definition for* `\__template_execute_if_keytype_exist:nT`.)

`\__template_execute_if_type_exist:nT` To check that a particular type is valid.

```
\cs_new_protected:Npn \__template_execute_if_type_exist:nT #1#2
  {
    \prop_if_in:NnTF \g__template_type_prop {#1}
      {#2}
      { \msg_error:nnn { template } { unknown-type } {#1} }
  }
```

(*End of definition for* `\__template_execute_if_type_exist:nT`.)

`\__template_execute_if_keys_exist:nnT` To check that the keys for a template have been set up before trying to create any code, a simple check for the correctly-named keytype property list.

```
\cs_new_protected:Npn \__template_if_keys_exist:nnT #1#2#3
  {
    \cs_if_exist:cTF { \c__template_keytypes_root_tl #1 / #2 }
      {#3}
      { \msg_error:nnnn { template } { unknown-template } {#1} {#2} }
   }
```

(*End of definition for* `\__template_execute_if_keys_exist:nnT`.)

`\__template_if_key_value:nTF` `\__template_if_key_value:VTF` Tests for the first token in a string being `\KeyValue`.

```
\prg_new_conditional:Npnn \__template_if_key_value:n #1 { T , F , TF }
  {
    \str_if_eq:noTF { \KeyValue } { \tl_head:w #1 \q_nil \q_stop }
      \prg_return_true:
      \prg_return_false:
  }
\prg_generate_conditional_variant:Nnn \__template_if_key_value:n { V } { T , F , TF }
```

(*End of definition for* `\__template_if_key_value:nTF`.)

`\__template_if_instance_exist:nnTF` Testing for an instance

```
\prg_new_conditional:Npnn \__template_if_instance_exist:nn #1#2 { T, F, TF }
  {
    \cs_if_exist:cTF { \c__template_instances_root_tl #1 / #2 }
      \prg_return_true:
      \prg_return_false:
 }
```

(*End of definition for* `\__template_if_instance_exist:nnTF`.)

`\__template_if_use_template:nTF` Tests for the first token in a string being `\UseTemplate`.

```
\prg_new_conditional:Npnn \__template_if_use_template:n #1 { TF }
  {
    \str_if_eq:noTF { \UseTemplate } { \tl_head:w #1 \q_nil \q_stop }
      \prg_return_true:
      \prg_return_false:
}
```

(*End of definition for* `\__template_if_use_template:nTF`.)

11.3 Saving and recovering property lists

The various property lists for templates have to be shuffled in and out of storage.

__template_store_defaults:nn
__template_store_keytypes:nn
__template_store_values:nn
__template_store_vars:nn

The defaults and keytypes are transferred from the scratch property lists to the "proper" lists for the template being created.

```
\cs_new_protected:Npn \__template_store_defaults:nn #1#2
  {
    \debug_suspend:
    \prop_gclear_new:c { \c__template_defaults_root_tl #1 / #2  }
    \prop_gset_eq:cN { \c__template_defaults_root_tl #1 / #2 }
      \l__template_values_prop
    \debug_resume:
  }
\cs_new_protected:Npn \__template_store_keytypes:nn #1#2
  {
    \debug_suspend:
    \prop_if_exist:cTF { \c__template_keytypes_root_tl #1 / #2 }
      {
        \msg_info:nnnn { template } { declare-template-interface } {#1} {#2}
        \prop_gclear:c { \c__template_keytypes_root_tl #1 / #2 }
      }
      { \prop_new:c { \c__template_keytypes_root_tl #1 / #2 } }
    \prop_gset_eq:cN { \c__template_keytypes_root_tl #1 / #2 }
      \l__template_keytypes_prop
    \seq_gclear_new:c { \c__template_key_order_root_tl #1 / #2 }
    \seq_gset_eq:cN { \c__template_key_order_root_tl #1 / #2 }
      \l__template_key_order_seq
    \debug_resume:
  }
\cs_new_protected:Npn \__template_store_values:nn #1#2
  {
    \debug_suspend:
    \prop_clear_new:c { \c__template_values_root_tl #1 / #2 }
    \prop_set_eq:cN { \c__template_values_root_tl #1 / #2 }
      \l__template_values_prop
    \debug_resume:
  }
\cs_new_protected:Npn \__template_store_vars:nn #1#2
  {
   \debug_suspend:
    \prop_gclear_new:c { \c__template_vars_root_tl #1 / #2 }
    \prop_gset_eq:cN { \c__template_vars_root_tl #1 / #2 }
      \l__template_vars_prop
    \debug_resume:
  }
```

(*End of definition for* `\__template_store_defaults:nn` *and others.*)

__template_recover_defaults:nn
__template_recover_keytypes:nn
__template_recover_values:nn
__template_recover_vars:nn

Recovering the stored data for a template is rather less complex than storing it. All that happens is the data is transferred from the permanent to the scratch storage. However, we need to check the scratch storage does exist.

```
\cs_new_protected:Npn \__template_recover_defaults:nn #1#2
  {
```

```
    \prop_if_exist:cTF
      { \c__template_defaults_root_tl #1 / #2 }
      {
        \prop_set_eq:Nc \l__template_values_prop
          { \c__template_defaults_root_tl #1 / #2 }
      }
      { \prop_clear:N \l__template_values_prop }
  }
\cs_new_protected:Npn \__template_recover_keytypes:nn #1#2
  {
    \prop_if_exist:cTF
      { \c__template_keytypes_root_tl #1 / #2 }
      {
        \prop_set_eq:Nc \l__template_keytypes_prop
          { \c__template_keytypes_root_tl #1 / #2 }
      }
      { \prop_clear:N \l__template_keytypes_prop }
    \seq_if_exist:cTF { \c__template_key_order_root_tl #1 / #2 }
      {
        \seq_set_eq:Nc \l__template_key_order_seq
          { \c__template_key_order_root_tl #1 / #2 }
      }
      { \seq_clear:N \l__template_key_order_seq }
  }
\cs_new_protected:Npn \__template_recover_values:nn #1#2
  {
    \prop_if_exist:cTF
      { \c__template_values_root_tl #1 / #2 }
      {
        \prop_set_eq:Nc \l__template_values_prop
          { \c__template_values_root_tl #1 / #2 }
      }
      { \prop_clear:N \l__template_values_prop }
  }
\cs_new_protected:Npn \__template_recover_vars:nn #1#2
  {
    \prop_if_exist:cTF
      { \c__template_vars_root_tl #1 / #2 }
      {
        \prop_set_eq:Nc \l__template_vars_prop
          { \c__template_vars_root_tl #1 / #2 }
      }
      { \prop_clear:N \l__template_vars_prop }
  }
```

(*End of definition for* `\__template_recover_defaults:nn` *and others.*)

11.4 Creating new template types

`\__template_define_type:nn`
`\__template_declare_type:nn`

Although the type is the "top level" of the template system, it is actually very easy to implement. All that happens is that the number of arguments required is recorded, indexed by the name of the type.

```
\cs_new_protected:Npn \__template_define_type:nn #1#2
  {
```

```
    \prop_if_in:NnTF \g__template_type_prop {#1}
      { \msg_error:nnn { template } { type-already-defined } {#1} }
      { \__template_declare_type:nn {#1} {#2} }
  }
\cs_new_protected:Npn \__template_declare_type:nn #1#2
  {
    \int_set:Nn \l__template_tmp_int {#2}
    \int_compare:nTF { 0 <= \l__template_tmp_int <= 9 }
      {
        \msg_info:nnnV { template } { declare-type }
          {#1} \l__template_tmp_int
        \prop_gput:NnV \g__template_type_prop {#1}
          \l__template_tmp_int
      }
      {
        \msg_error:nnnV { template } { bad-number-of-arguments }
          {#1} \l__template_tmp_int
      }
  }
```

(*End of definition for* `\__template_define_type:nn` *and* `\__template_declare_type:nn`.)

11.5 Design part of template declaration

The "design" part of a template declaration defines the general behaviour of each key, and possibly a default value. However, it does not include the implementation. This means that what happens here is the two properties are saved to appropriate lists, which can then be used later to recover the information when implementing the keys.

`\__template_declare_template_keys:nnnn`

The main function for the "design" part of creating a template starts by checking that the type exists and that the number of arguments required agree. If that is all fine, then the two storage areas for defaults and keytypes are initialised. The mechanism is then set up for the l3keys module to actually parse the keys. Finally, the code hands of to the storage routine to save the parsed information properly.

```
\cs_new_protected:Npn \__template_declare_template_keys:nnnn #1#2#3#4
  {
    \__template_execute_if_type_exist:nT {#1}
      {
        \__template_execute_if_arg_agree:nnT {#1} {#3}
          {
            \prop_clear:N \l__template_values_prop
            \prop_clear:N \l__template_keytypes_prop
            \seq_clear:N \l__template_key_order_seq
            \keyval_parse:NNn
              \__template_parse_keys_elt:n \__template_parse_keys_elt:nn {#4}
            \__template_store_defaults:nn {#1} {#2}
            \__template_store_keytypes:nn {#1} {#2}
          }
      }
  }
```

(*End of definition for* `\__template_declare_template_keys:nnnn`.)

__template_parse_keys_elt:n
__template_parse_keys_elt_aux:n
__template_parse_keys_elt_aux:

Processing the key part of the key–value pair is always carried out using this function, even if a value was found. First, the key name is separated from the keytype, and if necessary the keytype is separated into two parts. This information is then used to check that the keytype is valid, before storing the keytype (plus argument if necessary) as a property of the key name. The key name is also stored (in braces) in the token list to record the order the keys are defined in.

```
\cs_new_protected:Npn \__template_parse_keys_elt:n #1
  {
    \__template_split_keytype:n {#1}
    \bool_if:NF \l__template_error_bool
      {
        \__template_execute_if_keytype_exist:VT \l__template_keytype_tl
          {
            \seq_map_function:NN \c__template_keytypes_arg_seq
              \__template_parse_keys_elt_aux:n
            \bool_if:NF \l__template_error_bool
              {
                \seq_if_in:NoTF \l__template_key_order_seq
                  \l__template_key_name_tl
                  {
                    \msg_error:nnV { template } { duplicate-key-interface }
                      \l__template_key_name_tl
                  }
                  { \__template_parse_keys_elt_aux: }
              }
          }
      }
  }
\cs_new_protected:Npn \__template_parse_keys_elt_aux:n #1
  {
    \str_if_eq:VnT \l__template_keytype_tl {#1}
      {
        \tl_if_empty:NT \l__template_keytype_arg_tl
          {
            \msg_error:nnn { template } { keytype-requires-argument } {#1}
            \bool_set_true:N \l__template_error_bool
            \seq_map_break:
          }
      }
  }
\cs_new_protected:Npn \__template_parse_keys_elt_aux:
  {
    \tl_set:Ne \l__template_tmp_tl
      {
        \l__template_keytype_tl
        \tl_if_empty:NF \l__template_keytype_arg_tl
          { { \l__template_keytype_arg_tl } }
      }
    \prop_put:NVV \l__template_keytypes_prop \l__template_key_name_tl
      \l__template_tmp_tl
    \seq_put_right:NV \l__template_key_order_seq \l__template_key_name_tl
    \str_if_eq:VnT \l__template_keytype_tl { choice }
      {
```

```
        \clist_if_in:NnT \l__template_keytype_arg_tl { unknown }
          { \msg_error:nn { template } { choice-unknown-reserved } }
      }
  }
```

(*End of definition for* `\__template_parse_keys_elt:n`, `\__template_parse_keys_elt_aux:n`, *and* `\__template_parse_keys_elt_aux:`.)

`\__template_parse_keys_elt:nn` For keys which have a default, the keytype and key name are first separated out by the `\__template_parse_keys_elt:n` routine, before storing the default value in the scratch property list.

```
\cs_new_protected:Npn \__template_parse_keys_elt:nn #1#2
  {
    \__template_parse_keys_elt:n {#1}
    \use:c { __template_store_value_ \l__template_keytype_tl :n } {#2}
  }
```

(*End of definition for* `\__template_parse_keys_elt:nn`.)

`\__template_split_keytype:n` `\__template_split_keytype_aux:w` The keytype and key name should be separated by `:`. As the definition might be given inside or outside of a code block, the category code of colons is standardised. After that, the standard delimited argument method is used to separate the two parts.

```
\cs_new_protected:Npe \__template_split_keytype:n #1
  {
    \exp_not:N \bool_set_false:N \exp_not:N \l__template_error_bool
    \tl_set:Nn \exp_not:N \l__template_tmp_tl {#1}
    \tl_replace_all:Nnn \exp_not:N \l__template_tmp_tl { : } { \token_to_str:N : }
    \tl_if_in:VnTF \exp_not:N \l__template_tmp_tl { \token_to_str:N : }
      {
        \exp_not:n
          {
            \tl_clear:N \l__template_key_name_tl
            \exp_after:wN \__template_split_keytype_aux:w
              \l__template_tmp_tl \s__template_stop
          }
      }
      {
        \exp_not:N \bool_set_true:N \exp_not:N \l__template_error_bool
        \msg_error:nnn { template } { missing-keytype } {#1}
      }
  }
\use:e
  {
    \cs_new_protected:Npn \exp_not:N \__template_split_keytype_aux:w
      #1 \token_to_str:N : #2 \s__template_stop
      {
        \tl_put_right:Ne \exp_not:N \l__template_key_name_tl
          {
            \exp_not:N \tl_trim_spaces:e
              { \exp_not:N \tl_to_str:n {#1} }
          }
        \tl_if_in:nnTF {#2} { \token_to_str:N : }
          {
            \tl_put_right:Nn \exp_not:N \l__template_key_name_tl
```

```
              { \token_to_str:N : }
            \exp_not:N \__template_split_keytype_aux:w #2 \s__template_stop
          }
          {
            \exp_not:N \tl_if_empty:NTF \exp_not:N \l__template_key_name_tl
              {
                \msg_error:nnn { template } { empty-key-name }
                  { \token_to_str:N : #2 }
              }
              { \exp_not:N \__template_split_keytype_arg:n {#2} }
          }
      }
  }
```

(*End of definition for* `\__template_split_keytype:n` *and* `\__template_split_keytype_aux:w`.)

`\__template_split_keytype_arg:n`
`\__template_split_keytype_arg:V`
`\__template_split_keytype_arg_aux:n`
`\__template_split_keytype_arg_aux:w`

The second stage of sorting out the keytype is to check for an argument. As there is no convenient delimiting token to look for, a check is made instead for each possible text value for the keytype. To keep things faster, this only involves the keytypes that need an argument. If a match is made, then a check is also needed to see that it is at the start of the keytype information. All being well, the split can then be applied. Any non-matching keytypes are assumed to be "correct" as given, and are left alone (this is checked by other code).

```
\cs_new_protected:Npn \__template_split_keytype_arg:n #1
  {
    \tl_set:Ne \l__template_keytype_tl { \tl_trim_spaces:n {#1} }
    \tl_clear:N \l__template_keytype_arg_tl
    \cs_set_protected:Npn \__template_split_keytype_arg_aux:n ##1
      {
        \tl_if_in:nnT {#1} {##1}
          {
            \cs_set:Npn \__template_split_keytype_arg_aux:w
              ####1 ##1 ####2 \s__template_stop
              {
                \tl_if_blank:nT {####1}
                  {
                    \tl_set:Ne \l__template_keytype_tl
                      { \tl_trim_spaces:n {##1} }
                    \tl_if_blank:nF {####2}
                      {
                        \tl_set:Ne \l__template_keytype_arg_tl
                          { \use:n ####2 }
                      }
                    \seq_map_break:
                  }
              }
            \__template_split_keytype_arg_aux:w #1 \s__template_stop
          }
      }
    \seq_map_function:NN \c__template_keytypes_arg_seq
      \__template_split_keytype_arg_aux:n
  }
\cs_generate_variant:Nn \__template_split_keytype_arg:n { V }
\cs_new:Npn \__template_split_keytype_arg_aux:n #1 { }
```

```
\cs_new:Npn \__template_split_keytype_arg_aux:w #1 \s__template_stop { }
```

(*End of definition for* `\__template_split_keytype_arg:n`, `\__template_split_keytype_arg_aux:n`, *and* `\__template_split_keytype_arg_aux:w`.)

11.5.1 Storing values

As lttemplates pre-processes key values for efficiency reasons, there is a need to convert the values given as defaults into "ready to use" data. The same general idea is true when an instance is declared. However, assignments are not made until an instance is used, and so there has to be some intermediate storage. Furthermore, the ability to delay evaluation of results is needed. To achieve these aims, a series of "process and store" functions are defined here.

All of the information about the key (the key name and the keytype) is already stored as variables. The same property list is always used to store the data, meaning that the only argument required is the value to be processed and potentially stored.

`\__template_store_value_boolean:n`

```
\cs_new_protected:Npn \__template_store_value_boolean:n #1
  { \prop_put:Non \l__template_values_prop \l__template_key_name_tl {#1} }
```

(*End of definition for* `\__template_store_value_boolean:n`.)

`\__template_store_value:n`
`\__template_store_value_choice:n`
`\__template_store_value_function:n`
`\__template_store_value_instance:n`

With no need to worry about delayed evaluation, these keytypes all just store the input directly.

```
\cs_new_protected:Npn \__template_store_value:n #1
  { \prop_put:Non \l__template_values_prop \l__template_key_name_tl {#1} }
\cs_new_eq:NN \__template_store_value_choice:n    \__template_store_value:n
\cs_new_eq:NN \__template_store_value_function:n  \__template_store_value:n
\cs_new_eq:NN \__template_store_value_instance:n  \__template_store_value:n
```

(*End of definition for* `\__template_store_value:n` *and others.*)

`\__template_store_value_aux:Nn`
`\__template_store_value_integer:n`
`\__template_store_value_length:n`
`\__template_store_value_muskip:n`
`\__template_store_value_real:n`
`\__template_store_value_skip:n`
`\__template_store_value_tokenlist:n`
`\__template_store_value_commalist:n`

Storing values in `\l__template_values_prop` is in most cases the same.

```
\cs_new_protected:Npn \__template_store_value_aux:Nn #1#2
  { \prop_put:Non \l__template_values_prop \l__template_key_name_tl {#2} }
\cs_new_protected:Npn \__template_store_value_integer:n
  { \__template_store_value_aux:Nn \int_eval:n }
\cs_new_protected:Npn \__template_store_value_length:n
  { \__template_store_value_aux:Nn \dim_eval:n }
\cs_new_protected:Npn \__template_store_value_muskip:n
  { \__template_store_value_aux:Nn \muskip_eval:n }
\cs_new_protected:Npn \__template_store_value_real:n
  { \__template_store_value_aux:Nn \fp_eval:n }
\cs_new_protected:Npn \__template_store_value_skip:n
  { \__template_store_value_aux:Nn \skip_eval:n }
\cs_new_protected:Npn \__template_store_value_tokenlist:n
  { \__template_store_value_aux:Nn \use:n }
\cs_new_eq:NN \__template_store_value_commalist:n \__template_store_value_tokenlist:n
```

(*End of definition for* `\__template_store_value_aux:Nn` *and others.*)

11.6 Implementation part of template declaration

__template_declare_template_code:nnnnn
__template_declare_template_code:nnnn

The main function for implementing a template starts with a couple of simple checks to make sure that there are no obvious mistakes: the number of arguments must agree and the template keys must have been declared.

```
\cs_new_protected:Npn \__template_declare_template_code:nnnnn #1#2#3#4#5
  {
    \__template_execute_if_type_exist:nT {#1}
      {
        \__template_execute_if_arg_agree:nnT {#1} {#3}
          {
            \__template_if_keys_exist:nnT {#1} {#2}
              {
                \__template_store_key_implementation:nnn {#1} {#2} {#4}
                \str_if_in:nnTF {#5} { AssignTemplateKeys }
                  {
                    \regex_match:nnTF { \c { AssignTemplateKeys } } {#5}
                      { \__template_declare_template_code:nnnn {#1} {#2} {#3} {#5} }
                      {
                        \__template_declare_template_code:nnnn
                          {#1} {#2} {#3} { \AssignTemplateKeys #5 }
                      }
                  }
                  {
                    \__template_declare_template_code:nnnn
                      {#1} {#2} {#3} { \AssignTemplateKeys #5 }
                  }
              }
          }
      }
   }
\cs_new_protected:Npn \__template_declare_template_code:nnnn #1#2#3#4
  {
    \cs_if_exist:cT { \c__template_code_root_tl #1 / #2 }
      { \msg_info:nnnn { template } { declare-template-code } {#1} {#2} }
    \cs_generate_from_arg_count:cNnn
      { \c__template_code_root_tl #1 / #2 }
      \cs_gset_protected:Npn {#3} {#4}
  }
```

(*End of definition for* `\__template_declare_template_code:nnnnn` *and* `\__template_declare_template_code:nnnn`.)

__template_store_key_implementation:nnn

Actually storing the implementation part of a template is quite easy as it only requires the list of keys given to be turned into a property list. There is also some error-checking to do, hence the need to have the list of defined keytypes available. In certain cases (when choices are involved) parsing the key results in changes to the default values. That is why they are loaded and then saved again.

```
\cs_new_protected:Npn \__template_store_key_implementation:nnn #1#2#3
  {
    \__template_recover_defaults:nn {#1} {#2}
    \__template_recover_keytypes:nn {#1} {#2}
    \prop_clear:N \l__template_vars_prop
    \keyval_parse:nnn
```

```
      { \__template_parse_vars_elt:n } { \__template_parse_vars_elt:nnn { #1 / #2 } } {#3}
    \__template_store_vars:nn {#1} {#2}
    \prop_map_inline:Nn \l__template_keytypes_prop
      { \msg_error:nnnnn { template } { key-not-implemented } {##1} {#2} {#1} }
  }
```

(*End of definition for* `\__template_store_key_implementation:nnn`.)

`\__template_parse_vars_elt:n` At the implementation stage, every key must have a value given. So this is an error function.

```
\cs_new_protected:Npn \__template_parse_vars_elt:n #1
  { \msg_error:nnn { template } { key-no-variable } {#1} }
```

(*End of definition for* `\__template_parse_vars_elt:n`.)

`\__template_parse_vars_elt:nnn`
`\__template_parse_vars_elt_aux:nn`
`\__template_parse_vars_elt_aux:nw`
`\__template_parse_vars_elt_aux:nnn`
`\__template_parse_vars_elt_aux:nne`
`\__template_parse_vars_elt_key:nn`

The actual storage part here is very simple: the storage bin name is placed into the property list. At the same time, a comparison is made with the keytypes defined earlier: if there is a mismatch then an error is raised.

```
\cs_new_protected:Npn \__template_parse_vars_elt:nnn #1#2#3
 {
    \tl_set:Ne \l__template_key_name_tl
      { \tl_trim_spaces:e { \tl_to_str:n {#2} } }
    \prop_get:NVNTF \l__template_keytypes_prop
      \l__template_key_name_tl
      \l__template_keytype_tl
      {
        \__template_split_keytype_arg:V \l__template_keytype_tl
        \__template_parse_vars_elt_aux:nn {#1} {#3}
        \prop_remove:NV \l__template_keytypes_prop \l__template_key_name_tl
      }
      { \msg_error:nnn { template } { unknown-key } {#2} }
  }
```

Split off any leading `global` and they look for the way to implement.

```
\cs_new_protected:Npn \__template_parse_vars_elt_aux:nn #1#2
  {
    \__template_parse_vars_elt_aux:nw {#1} #2 global global \s__template_stop
  }
\cs_new_protected:Npn \__template_parse_vars_elt_aux:nw
  #1#2 global #3 global #4 \s__template_stop
  {
    \tl_if_blank:nTF {#4}
      { \__template_parse_vars_elt_aux:nnn {#1} { } {#2} }
      {
        \tl_if_blank:nTF {#2}
          {
            \__template_parse_vars_elt_aux:nne
              {#1} { global } { \tl_trim_spaces:n {#3} }
          }
          { \msg_error:nnn { template } { bad-variable } { #2 global #3 } }
      }
  }
\cs_new_protected:Npn \__template_parse_vars_elt_aux:nnn #1#2#3
  {
    \str_case:VnF \l__template_keytype_tl
```

```
      {
        { choice } { \__template_implement_choices:nn {#1} {#3} }
        { function }
          {
            \cs_if_exist:NF #3
              { \cs_new:Npn #3 { } }
            \__template_parse_vars_elt_key:nn {#1}
              {
                .code:n =
                  {
                    \cs_generate_from_arg_count:NNnn
                      \exp_not:N #3
                      \exp_not:c
                        { cs_ \str_if_eq:nnT {#1} { global } { g } set:Npn }
                      { \exp_not:V \l__template_keytype_arg_tl }
                      {##1}
                  }
              }
            \prop_put:NVn \l__template_vars_prop
              \l__template_key_name_tl {#2#3}
          }
        { instance }
          {
            \__template_parse_vars_elt_key:nn {#1}
              {
                .code:n =
                  {
                    \exp_not:c
                      { cs_ \str_if_eq:nnT {#1} { global } { g } set:Npn }
                      \exp_not:N #3 { \UseInstance {##1} }
                  }
              }
            \prop_put:NVn \l__template_vars_prop
              \l__template_key_name_tl {#2#3}
          }
      }
      {
        \tl_if_single:nTF {#3}
          {
            \cs_if_exist:NF #3
              { \use:c { \__template_map_var_type: _new:N } #3 }
            \__template_parse_vars_elt_key:nn {#1}
              {
                . \__template_map_var_type:
                  _ \str_if_eq:nnT {#1} { global } { g } set:N
                    = \exp_not:N #3
              }
            \prop_put:NVn \l__template_vars_prop
              \l__template_key_name_tl {#2#3}
          }
          { \msg_error:nnn { template } { bad-variable } {#2#3} }
      }
  }
\cs_generate_variant:Nn \__template_parse_vars_elt_aux:nnn { nne }
```

```
\cs_new_protected:Npn \__template_parse_vars_elt_key:nn #1#2
  {
    \keys_define:ne { template / #1 }
      { \l__template_key_name_tl #2 }
  }
```

(*End of definition for* `\__template_parse_vars_elt:nnn` *and others.*)

`\__template_map_var_type:` Turn a "friendly" variable type into an `expl3` one.

```
\cs_new:Npn \__template_map_var_type:
  {
    \str_case:Vn \l__template_keytype_tl
      {
        { boolean }   { bool }
        { commalist } { clist }
        { integer }   { int }
        { length }    { dim }
        { muskip }    { muskip }
        { real }      { fp }
        { skip }      { skip }
        { tokenlist } { tl }
      }
  }
```

(*End of definition for* `\__template_map_var_type:`.)

`\__template_implement_choices:nn` `\__template_implement_choices_default:` Implementing choices requires a second key–value loop. So after a little set-up, the standard parser is called.

```
\cs_new_protected:Npn \__template_implement_choices:nn #1#2
  {
    \clist_set:NV \l__template_tmp_clist \l__template_keytype_arg_tl
    \prop_put:NVn \l__template_vars_prop \l__template_key_name_tl { }
    \keys_define:ne { template / #1 } { \l__template_key_name_tl .choice: }
    \keyval_parse:nnn
      { \__template_implement_choice_elt:n }
      { \__template_implement_choice_elt:nnn {#1} }
      {#2}
    \prop_get:NVNT \l__template_values_prop \l__template_key_name_tl
      \l__template_tmp_tl
      { \__template_implement_choices_default: }
    \clist_if_empty:NF \l__template_tmp_clist
      {
        \clist_map_inline:Nn \l__template_tmp_clist
          { \msg_error:nnn { template } { choice-not-implemented } {##1} }
      }
  }
```

A sanity check for the default value, so that an error is raised now and not when converting to assignments.

```
\cs_new_protected:Npn \__template_implement_choices_default:
  {
    \tl_set:Ne \l__template_tmp_tl
      { \l__template_key_name_tl \c_space_tl \l__template_tmp_tl }
    \prop_if_in:NVF \l__template_vars_prop \l__template_tmp_tl
      {
```

```
        \tl_set:Ne \l__template_tmp_tl
          { \l__template_key_name_tl \c_space_tl \l__template_tmp_tl }
        \prop_if_in:NVF \l__template_vars_prop \l__template_tmp_tl
          {
            \prop_get:NVN \l__template_keytypes_prop \l__template_key_name_tl
              \l__template_tmp_tl
            \__template_split_keytype_arg:V \l__template_tmp_tl
            \prop_get:NVN \l__template_values_prop \l__template_key_name_tl
              \l__template_tmp_tl
            \msg_error:nnVV { template } { unknown-default-choice }
              \l__template_key_name_tl
              \l__template_key_name_tl
          }
      }
  }
```

(*End of definition for* `\__template_implement_choices:nn` *and* `\__template_implement_choices_-default:`.)

`\__template_implement_choice_elt:nnn`
`\__template_implement_choice_elt_aux:nnn`
`\__template_implement_choice_elt_aux:n`
`\__template_implement_choice_elt:n`

The actual storage of the implementation of a choice is mainly about error checking. The code here ensures that all choices have to have been declared, apart from the special `unknown` choice, which must come last. The code for each choice is stored along with the key name in the variables property list.

```
\cs_new_protected:Npn \__template_implement_choice_elt:nnn #1#2#3
  {
    \clist_if_empty:NTF \l__template_tmp_clist
      {
        \str_if_eq:nnTF {#2} { unknown }
          { \__template_implement_choice_elt_aux:nnn {#1} {#2} {#3} }
          { \__template_implement_choice_elt_aux:n {#2} }
      }
      {
        \clist_if_in:NnTF \l__template_tmp_clist {#2}
          {
            \clist_remove_all:Nn \l__template_tmp_clist {#2}
            \__template_implement_choice_elt_aux:nnn {#1} {#2} {#3}
          }
          { \__template_implement_choice_elt_aux:n {#2} }
      }
  }
\cs_new_protected:Npn \__template_implement_choice_elt_aux:n #1
  {
    \prop_get:NVN \l__template_keytypes_prop \l__template_key_name_tl
      \l__template_tmp_tl
    \__template_split_keytype_arg:V \l__template_tmp_tl
    \msg_error:nnVn { template } { unknown-choice } \l__template_key_name_tl {#1}
  }
\cs_new_protected:Npn \__template_implement_choice_elt_aux:nnn #1#2#3
  {
    \keys_define:ne { template / #1 }
      { \l__template_key_name_tl / #2 .code:n = { \exp_not:n {#3} } }
    \tl_set:Ne \l__template_tmp_tl
      { \l__template_key_name_tl \c_space_tl #2 }
    \prop_put:NVn \l__template_vars_prop \l__template_tmp_tl {#3}
```

```
  }
\cs_new_protected:Npn \__template_implement_choice_elt:n #1
  {
    \msg_error:nnVn { template } { choice-requires-code }
      \l__template_key_name_tl {#1}
  }
```

(*End of definition for* `\__template_implement_choice_elt:nnn` *and others.*)

11.7 Editing template defaults

`\__template_edit_defaults:nnn` Editing the template defaults means getting the values back out of the store, then parsing the list of new values before putting the updated list back into storage.

```
\cs_new_protected:Npn \__template_edit_defaults:nnn #1#2#3
  {
    \__template_if_keys_exist:nnT {#1} {#2}
      {
        \__template_recover_defaults:nn {#1} {#2}
        \__template_parse_values:nnn {#1} {#2} {#3}
        \__template_store_defaults:nn {#1} {#2}
      }
  }
```

(*End of definition for* `\__template_edit_defaults:nnn`.)

`\__template_parse_values:nnn` The routine to parse values is the same for both editing a template and setting up an instance. So the code here does only the minimum necessary for reading the values.

```
\cs_new_protected:Npn \__template_parse_values:nnn #1#2#3
  {
    \__template_recover_keytypes:nn {#1} {#2}
    \keyval_parse:NNn
      \__template_parse_values_elt:n \__template_parse_values_elt:nn {#3}
  }
```

(*End of definition for* `\__template_parse_values:nnn`.)

`\__template_parse_values_elt:n` Every key needs a value, so this is just an error routine.

```
\cs_new_protected:Npn \__template_parse_values_elt:n #1
  {
    \bool_set_true:N \l__template_error_bool
    \msg_error:nnn { template } { key-no-value } {#1}
  }
```

(*End of definition for* `\__template_parse_values_elt:n`.)

`\__template_parse_values_elt:nn` `\__template_parse_values_elt_aux:w` `\__template_parse_values_elt_aux:n` `\__template_parse_values_exp:n` `\__template_parse_values_exp:o` `\__template_parse_values_exp:V` `\__template_parse_values_exp:v` `\__template_parse_values_exp:e` `\__template_parse_values_exp:N` `\__template_parse_values_exp:c` To store the value, find the keytype then call the saving function. These need the current key name, stored in `\l__template_key_name_tl`.

```
\cs_new_protected:Npn \__template_parse_values_elt:nn #1#2
  {
    \use:e
      {
        \__template_parse_values_elt_aux:w
          \tl_trim_spaces:e { \tl_to_str:n { #1 : n : } }
          \exp_not:N \q_stop
```

```
      }
    \prop_get:NVNTF \l__template_keytypes_prop \l__template_key_name_tl
      \l__template_tmp_tl
      { \__template_parse_values_elt_aux:n {#2} }
      { \msg_error:nnV { template } { unknown-key } \l__template_key_name_tl }
  }
\use:e
  {
    \cs_new_protected:Npn \exp_not:N \__template_parse_values_elt_aux:w
      #1 \token_to_str:N : #2 \token_to_str:N : #3 \exp_not:N \q_stop
  }
    {
      \tl_set:Nn \l__template_key_name_tl {#1}
      \str_set:Nn \l__template_value_exp_str {#2}
    }
\cs_new_protected:Npn \__template_parse_values_elt_aux:n #1
  {
    \__template_split_keytype_arg:V \l__template_tmp_tl
    \cs_if_exist_use:cF { __template_parse_values_exp: \l__template_value_exp_str }
      {
        \msg_error:nnV { template } { unknown-expansion } \l__template_value_exp_str
        \use_none:n
      }
        {#1}
  }
\cs_new_protected:Npn \__template_parse_values_exp:n #1
  { \use:c { __template_store_value_ \l__template_keytype_tl :n } {#1} }
\cs_generate_variant:Nn \__template_parse_values_exp:n { o , V , v , e }
\cs_new_eq:NN \__template_parse_values_exp:N \__template_parse_values_exp:n
\cs_generate_variant:Nn \__template_parse_values_exp:N  { c }
```

(*End of definition for* `\__template_parse_values_elt:nn` *and others.*)

`\__template_template_set_eq:nnn` To copy a template, each of the lists plus the code has to be copied across. To keep this independent of the list storage system, it is all done with two-part shuffles.

```
\cs_new_protected:Npn \__template_template_set_eq:nnn #1#2#3
  {
    \__template_recover_defaults:nn {#1} {#3}
    \__template_store_defaults:nn {#1} {#2}
    \__template_recover_keytypes:nn {#1} {#3}
    \__template_store_keytypes:nn {#1} {#2}
    \__template_recover_vars:nn {#1} {#3}
    \__template_store_vars:nn {#1} {#2}
    \cs_if_exist:cT { \c__template_code_root_tl #1 / #2 }
      { \msg_info:nnnn { template } { declare-template-code } {#1} {#2} }
    \cs_gset_eq:cc { \c__template_code_root_tl #1 / #2 }
      { \c__template_code_root_tl #1 / #3 }
  }
```

(*End of definition for* `\__template_template_set_eq:nnn`.)

11.8 Creating instances of templates

`\__template_declare_instance:nnnn` `\__template_declare_instance_aux:nnnn` Making an instance has two distinct parts. First, the keys given are parsed to transfer the values into the structured data format used internally. This allows the default and

given values to be combined with no repetition. In the second step, the structured data is converted to pre-defined variable assignments, and these are stored in the function for the instance.

```
\cs_new_protected:Npn \__template_declare_instance:nnnn #1#2#3#4
  {
    \__template_execute_if_code_exist:nnT {#1} {#2}
      {
        \__template_recover_defaults:nn {#1} {#2}
        \__template_recover_vars:nn {#1} {#2}
        \__template_declare_instance_aux:nnnn {#1} {#2} {#3} {#4}
      }
  }
\cs_new_protected:Npn \__template_declare_instance_aux:nnnn #1#2#3#4
  {
    \bool_set_false:N \l__template_error_bool
    \__template_parse_values:nnn {#1} {#2} {#4}
    \bool_if:NF \l__template_error_bool
      {
        \prop_put:Nnn \l__template_values_prop { from~template } {#2}
        \__template_store_values:nn {#1} {#3}
        \__template_convert_to_assignments:
        \cs_if_exist:cT { \c__template_instances_root_tl #1 / #3 }
          { \msg_info:nnnn { template } { declare-instance } {#3} {#1} }
        \cs_set_protected:cpe { \c__template_instances_root_tl #1 / #3 }
          {
            \exp_not:N \__template_assignments_push:n
              { \exp_not:V \l__template_assignments_tl }
            \exp_not:c { \c__template_code_root_tl #1 / #2 }
          }
      }
  }
```

(*End of definition for* `\__template_declare_instance:nnnn` *and* `\__template_declare_instance_aux:nnnn`.)

`\__template_instance_set_eq:nnn` Copy–paste an instance.

```
\cs_new_protected:Npn \__template_instance_set_eq:nnn #1#2#3
  {
    \__template_if_instance_exist:nnTF {#1} {#3}
      {
        \__template_recover_values:nn {#1} {#3}
        \__template_store_values:nn {#1} {#2}
        \cs_if_exist:cT { \c__template_instances_root_tl #1 / #2 }
          { \msg_info:nnnn { template } { declare-instance } {#2} {#1} }
        \cs_set_eq:cc { \c__template_instances_root_tl #1 / #2 }
          { \c__template_instances_root_tl #1 / #3 }
      }
      { \msg_error:nnnn { template } { unknown-instance } {#1} {#3} }
  }
```

(*End of definition for* `\__template_instance_set_eq:nnn`.)

`\__template_edit_instance:nnn` Editing an instance is almost identical to declaring one. The only variation is the source
`\__template_edit_instance_aux:nnnnn` of the values to use. When editing, they are recovered from the previous instance run.
`\__template_edit_instance_aux:nVnnn`

```
\cs_new_protected:Npn \__template_edit_instance:nnn #1#2#3
  {
    \__template_if_instance_exist:nnTF {#1} {#2}
      {
        \__template_recover_values:nn {#1}  {#2}
        \prop_get:NnN \l__template_values_prop { from~template }
          \l__template_tmp_tl
        \__template_edit_instance_aux:nVnn
          {#1} \l__template_tmp_tl {#2} {#3}
      }
      { \msg_error:nnnn { template } { unknown-instance } {#1} {#2} }
  }
\cs_new_protected:Npn \__template_edit_instance_aux:nnnn #1#2#3#4
  {
    \__template_recover_vars:nn {#1} {#2}
    \__template_declare_instance_aux:nnnn {#1} {#2} {#3} {#4}
  }
\cs_generate_variant:Nn \__template_edit_instance_aux:nnnn { nV }
```

(*End of definition for* `\__template_edit_instance:nnn` *and* `\__template_edit_instance_aux:nnnnn`.)

`\__template_convert_to_assignments:`
`\__template_convert_to_assignments_aux:n`
`\__template_convert_to_assignments_aux:nn`
`\__template_convert_to_assignments_aux:nV`

The idea on converting to a set of assignments is to loop over each key, so that the loop order follows the declaration order of the keys. This is done using a sequence as property lists are not "ordered".

```
\cs_new_protected:Npn \__template_convert_to_assignments:
  {
    \tl_clear:N \l__template_assignments_tl
    \seq_map_function:NN \l__template_key_order_seq
      \__template_convert_to_assignments_aux:n
  }
\cs_new_protected:Npn \__template_convert_to_assignments_aux:n #1
  {
    \prop_get:NnN \l__template_keytypes_prop {#1} \l__template_tmp_tl
    \__template_convert_to_assignments_aux:nV {#1} \l__template_tmp_tl
  }
```

The second auxiliary function actually does the work. The arguments here are the key name (`#1`) and the keytype (`#2`). From those, the value to assign and the name of the appropriate variable are recovered. A bit of work is then needed to sort out keytypes with arguments (for example instances), and to look for global assignments. Once that is done, a hand-off can be made to the handler for the relevant keytype.

```
\cs_new_protected:Npn \__template_convert_to_assignments_aux:nn #1#2
  {
    \prop_get:NnNT \l__template_values_prop {#1} \l__template_value_tl
      {
        \prop_get:NnNTF \l__template_vars_prop {#1} \l__template_var_tl
          {
            \__template_split_keytype_arg:n {#2}
            \str_if_eq:VnF \l__template_keytype_tl { choice }
              {
                \str_if_eq:VnF \l__template_keytype_tl { code }
                  { \__template_find_global: }
              }
            \tl_set:Nn \l__template_key_name_tl {#1}
```

```
            \cs_if_exist_use:cF { __template_assign_ \l__template_keytype_tl : }
              { \__template_assign_variable: }
          }
          { \msg_error:nnn { template } { unknown-attribute } {#1} }
      }
  }
\cs_generate_variant:Nn \__template_convert_to_assignments_aux:nn { nV }
```

(*End of definition for* `\__template_convert_to_assignments:`, `\__template_convert_to_assignments_aux:n`, *and* `\__template_convert_to_assignments_aux:nn`.)

`\__template_find_global:`
`\__template_find_global_aux:w`

Global assignments should have the phrase `global` at the front. This is pretty easy to find: no other error checking, though.

```
\cs_new_protected:Npn \__template_find_global:
  {
    \bool_set_false:N \l__template_global_bool
    \tl_if_in:onT \l__template_var_tl { global }
      {
        \exp_after:wN \__template_find_global_aux:w \l__template_var_tl \s__template_stop
      }
  }
\cs_new_protected:Npn \__template_find_global_aux:w  #1 global #2 \s__template_stop
  {
    \tl_set:Nn \l__template_var_tl {#2}
    \bool_set_true:N \l__template_global_bool
  }
```

(*End of definition for* `\__template_find_global:` *and* `\__template_find_global_aux:w`.)

11.9 Using templates directly

`\__template_use_template:nnn`

Directly use a template with a particular parameter setting. This is also picked up if used in a nested fashion inside a parameter list. The idea is essentially the same as creating an instance, just with no saving of the result.

```
\cs_new_protected:Npn \__template_use_template:nnn #1#2#3
  {
    \__template_execute_if_code_exist:nnT {#1} {#2}
      {
        \__template_recover_defaults:nn {#1} {#2}
        \__template_recover_vars:nn {#1} {#2}
        \__template_parse_values:nnn {#1} {#2} {#3}
        \__template_convert_to_assignments:
        \use:c { \c__template_code_root_tl #1 / #2  }
      }
  }
```

(*End of definition for* `\__template_use_template:nnn`.)

11.10 Assigning values to variables

`\__template_assign_boolean:`
`\__template_assign_boolean_aux:n`

Setting a Boolean value is slightly different to everything else as the value can be used to work out which `set` function to call. As long as there is no need to recover things from another variable, everything is pretty easy. If there is, then we need to allow for

the fact that the recovered value here will *not* be expandable, so needs to be converted to something that is.

```
\cs_new_protected:Npn \__template_assign_boolean:
  {
    \bool_if:NTF \l__template_global_bool
      { \__template_assign_boolean_aux:n { bool_gset } }
      { \__template_assign_boolean_aux:n { bool_set } }
  }
\cs_new_protected:Npn \__template_assign_boolean_aux:n #1
  {
    \__template_if_key_value:VTF \l__template_value_tl
      {
        \__template_key_to_value:
        \tl_put_right:Ne \l__template_assignments_tl
          {
            \exp_not:c { #1 _eq:NN }
            \exp_not:V \l__template_var_tl
            \exp_not:V \l__template_value_tl
          }
      }
      {
        \tl_put_right:Ne \l__template_assignments_tl
          {
            \exp_not:c { #1 _ \l__template_value_tl :N }
            \exp_not:V \l__template_var_tl
          }
      }
  }
```

(*End of definition for* `\__template_assign_boolean:` *and* `\__template_assign_boolean_aux:n`.)

`\__template_assign_choice:`
`\__template_assign_choice_aux:nF`
`\__template_assign_choice_aux:eF`

The idea here is to find either the choice as-given or else the special `unknown` choice, and to copy the appropriate code across.

```
\cs_new_protected:Npn \__template_assign_choice:
  {
    \__template_assign_choice_aux:eF
      { \l__template_key_name_tl \c_space_tl \l__template_value_tl }
      {
        \__template_assign_choice_aux:eF
          { \l__template_key_name_tl \c_space_tl unknown }
          {
            \prop_get:NVN \l__template_keytypes_prop \l__template_key_name_tl
              \l__template_tmp_tl
            \__template_split_keytype_arg:V \l__template_tmp_tl
            \msg_error:nnVV { template } { unknown-choice }
              \l__template_key_name_tl
              \l__template_value_tl
          }
      }
  }
\cs_new_protected:Npn \__template_assign_choice_aux:nF #1
  {
    \prop_get:NnNTF \l__template_vars_prop {#1} \l__template_tmp_tl
      { \tl_put_right:NV \l__template_assignments_tl \l__template_tmp_tl }
```

```
  }
\cs_generate_variant:Nn \__template_assign_choice_aux:nF { e }
```

(*End of definition for* `\__template_assign_choice:` *and* `\__template_assign_choice_aux:nF`.)

`\__template_assign_function:`
`\__template_assign_function_aux:N`

This looks a bit messy but is only actually one function.

```
\cs_new_protected:Npn \__template_assign_function:
  {
    \bool_if:NTF \l__template_global_bool
      { \__template_assign_function_aux:N \cs_gset:Npn }
      { \__template_assign_function_aux:N \cs_set:Npn  }
  }
\cs_new_protected:Npn \__template_assign_function_aux:N #1
  {
    \tl_put_right:Ne \l__template_assignments_tl
      {
        \cs_generate_from_arg_count:NNnn
          \exp_not:V \l__template_var_tl
          \exp_not:N #1
          { \exp_not:V \l__template_keytype_arg_tl }
          { \exp_not:V \l__template_value_tl }
      }
  }
```

(*End of definition for* `\__template_assign_function:` *and* `\__template_assign_function_aux:N`.)

`\__template_assign_instance:`
`\__template_assign_instance_aux:N`

Using an instance means adding the appropriate function creation to the tl. No checks are made at this stage, so if the instance is not valid then errors will arise later.

```
\cs_new_protected:Npn \__template_assign_instance:
  {
    \bool_if:NTF \l__template_global_bool
      { \__template_assign_instance_aux:N \cs_gset_protected:Npn }
      { \__template_assign_instance_aux:N \cs_set_protected:Npn  }
  }
\cs_new_protected:Npn \__template_assign_instance_aux:N #1
  {
    \tl_put_right:Ne \l__template_assignments_tl
      {
        \exp_not:N #1 \exp_not:V \l__template_var_tl
          {
            \__template_use_instance:nn
              { \exp_not:V \l__template_keytype_arg_tl }
              { \exp_not:V \l__template_value_tl }
          }
      }
  }
```

(*End of definition for* `\__template_assign_instance:` *and* `\__template_assign_instance_aux:N`.)

`\__template_assign_variable:`
`\__template_assign_variable:n`

A general-purpose function for all of the other assignments. As long as the value is not coming from another variable, the stored value is simply transferred for output. We use `V`-type expansion for the `\KeyValue` case: for token lists this is essential, whilst for register-based variables, it does no harm and avoids needing a low-level test.

```
\cs_new_protected:Npn \__template_assign_variable:
```

```
  {
    \exp_args:Ne \__template_assign_variable:n
      {
        \__template_map_var_type:
        _
        \bool_if:NT \l__template_global_bool { g }
        set:N
      }
  }
```

Notice we need a `V`-type variant for each `(g)set` operation here: these need to be provided by expl3.

```
\cs_new_protected:Npn \__template_assign_variable:n #1
  {
    \__template_if_key_value:VTF \l__template_value_tl
      {
        \__template_key_to_value:
        \tl_put_right:Ne \l__template_assignments_tl
          {
            \exp_not:c { #1 V } \exp_not:V \l__template_var_tl
             \exp_not:V \l__template_value_tl
          }
      }
      {
        \tl_put_right:Ne \l__template_assignments_tl
          {
            \exp_not:c { #1 n } \exp_not:V \l__template_var_tl
             { \exp_not:V \l__template_value_tl }
          }
      }
  }
```

(*End of definition for* `\__template_assign_variable:` *and* `\__template_assign_variable:n`.)

`\__template_key_to_value:`
`\__template_key_to_value_auxi:w`
`\__template_key_to_value_auxii:w`

The idea here is to recover the attribute value of another key. To do that, the marker is removed and a look up takes place. If this is successful, then the name of the variable of the attribute is returned. This assumes that the value will be used in context where it will be converted to a value, for example when setting a number. There is also a need to check in case the copied value happens to be `global`.

```
\cs_new_protected:Npn \__template_key_to_value:
  { \exp_after:wN \__template_key_to_value_auxi:w \l__template_value_tl }
\cs_new_protected:Npn \__template_key_to_value_auxi:w \KeyValue #1
  {
    \tl_set:Ne \l__template_tmp_tl { \tl_trim_spaces:e { \tl_to_str:n {#1} } }
    \prop_get:NVNTF \l__template_vars_prop \l__template_tmp_tl
      \l__template_value_tl
      {
        \exp_after:wN \__template_key_to_value_auxii:w \l__template_value_tl
          \s__template_mark global \q__template_nil \s__template_stop
      }
      { \msg_error:nnV { template } { unknown-attribute } \l__template_tmp_tl }
  }
\cs_new_protected:Npn \__template_key_to_value_auxii:w #1 global #2#3 \s__template_stop
  {
```

```
    \__template_quark_if_nil:NF #2
      { \tl_set:Nn \l__template_value_tl {#2} }
  }
```

(*End of definition for* `\__template_key_to_value:`, `\__template_key_to_value_auxi:w`, *and* `\__template_key_to_value_auxii:w`.)

11.11 Using instances

`\__template_use_instance:nn`
`\__template_use_instance_aux:nNnnn`
`\__template_use_instance_aux:nn`

Using an instance is just a question of finding the appropriate function. If nothing is found, an error is raised. One complication is that if the first token of argument `#2` is `\UseTemplate` then that is also valid. There is an error-test to make sure that the types agree, and if so the template is used directly.

```
\cs_new_protected:Npn \__template_use_instance:nn #1#2
  {
    \__template_if_use_template:nTF {#2}
      { \__template_use_instance_aux:nNnnn {#1} #2 }
      { \__template_use_instance_aux:nn {#1} {#2} }
  }
\cs_new_protected:Npn \__template_use_instance_aux:nNnnn #1#2#3#4#5
  {
    \str_if_eq:nnTF {#1} {#3}
      { \__template_use_template:nnn {#3} {#4} {#5} }
      { \msg_error:nnnn { template } { type-mismatch } {#1} {#3} }
}
\cs_new_protected:Npn \__template_use_instance_aux:nn #1#2
  {
    \__template_if_instance_exist:nnTF {#1} {#2}
      { \use:c { \c__template_instances_root_tl #1 / #2 } }
      { \msg_error:nnnn { template } { unknown-instance } {#1} {#2} }
  }
```

(*End of definition for* `\__template_use_instance:nn`, `\__template_use_instance_aux:nNnnn`, *and* `\__template_use_instance_aux:nn`.)

11.12 Assignment manipulation

A few functions to transfer assignments about, as this is needed by `\AssignTemplateKeys`.

`\__template_assignments_pop:`

To actually use the assignments.

```
\cs_new:Npn \__template_assignments_pop: { \l__template_assignments_tl }
```

(*End of definition for* `\__template_assignments_pop:`.)

`\__template_assignments_push:n`

Here, the assignments are stored for later use.

```
\cs_new_protected:Npn \__template_assignments_push:n #1
  { \tl_set:Nn \l__template_assignments_tl {#1} }
```

(*End of definition for* `\__template_assignments_push:n`.)

11.13 Showing templates and instances

__template_show_code:nn

Showing the code for a template is just a translation of \cs_show:c.

```
\cs_new_protected:Npn \__template_show_code:nn #1#2
  { \cs_show:c { \c__template_code_root_tl #1 / #2 } }
```

(*End of definition for* __template_show_code:nn.)

__template_show_defaults:nn
__template_show_keytypes:nn
__template_show_vars:nn
__template_show:Nnnn

A modified version of the property-list printing code, such that the output refers to templates and instances rather than to the underlying structures.

```
\cs_new_protected:Npn \__template_show_defaults:nn #1#2
  {
    \__template_if_keys_exist:nnT {#1} {#2}
      {
        \__template_recover_defaults:nn {#1} {#2}
        \__template_show:Nnnn \l__template_values_prop
          {#1} {#2} { default~values }
      }
  }
\cs_new_protected:Npn \__template_show_keytypes:nn #1#2
  {
    \__template_if_keys_exist:nnT {#1} {#2}
      {
        \__template_recover_keytypes:nn {#1} {#2}
        \__template_show:Nnnn \l__template_keytypes_prop
          {#1} {#2} { interface }
      }
  }
\cs_new_protected:Npn \__template_show_vars:nn #1#2
  {
     \__template_execute_if_code_exist:nnT {#1} {#2}
      {
        \__template_recover_vars:nn {#1} {#2}
        \__template_show:Nnnn \l__template_vars_prop
          {#1} {#2} { variable~mapping }
      }
  }
\cs_new_protected:Npn \__template_show:Nnnn #1#2#3#4
  {
    \msg_show:nneeee { template } { show-attribute }
      { \tl_to_str:n {#2} }
      { \tl_to_str:n {#3} }
      { \tl_to_str:n {#4} }
      { \prop_map_function:NN #1 \msg_show_item_unbraced:nn }
  }
```

(*End of definition for* __template_show_defaults:nn *and others.*)

__template_show_values:nn

Instance values are a little more complex, as is the template to consider.

```
\cs_new_protected:Npn \__template_show_values:nn #1#2
  {
    \__template_if_instance_exist:nnT {#1} {#2}
      {
        \__template_recover_values:nn {#1} {#2}
```

```
        \msg_show:nneee { template } { show-values }
          { \tl_to_str:n {#1} }
          { \tl_to_str:n {#2} }
          {
            \prop_map_function:NN \l__template_values_prop
              \msg_show_item_unbraced:nn
          }
      }
  }
```

(*End of definition for* `\__template_show_values:nn`.)

11.14 Messages

The text for error messages: short and long text for all of them.

```
\msg_new:nnnn { template } { argument-number-mismatch }
  { Template~type~'#1'~takes~#2~argument(s). }
  {
    Templates~of~type~'#1'~require~#2~argument(s).\\
    You~have~tried~to~make~a~template~for~'#1'~
    with~#3~argument(s),~which~is~not~possible:~
    the~number~of~arguments~must~agree.
  }
\msg_new:nnnn { template } { bad-number-of-arguments }
  { Bad~number~of~arguments~for~template~type~'#1'. }
  {
    A~template~may~accept~between~0~and~9~arguments.\\
    You~asked~to~use~#2~arguments:~this~is~not~supported.
  }
\msg_new:nnnn { template } { bad-variable }
  { Incorrect~variable~description~'#1'. }
  {
    The~argument~'#1'~is~not~of~the~form \\
    ~~'<variable>'\\
    ~or~\\
    ~~'global~<variable>'.\\
    It~must~be~given~in~one~of~these~formats~to~be~used~in~a~template.
  }
\msg_new:nnnn { template } { choice-not-implemented }
  { The~choice~'#1'~has~no~implementation. }
  {
    Each~choice~listed~in~the~interface~for~a~template~must~
    have~an~implementation.
  }
\msg_new:nnnn { template } { choice-no-code }
  { The~choice~'#1'~requires~implementation~details. }
  {
    When~creating~template~code~using~\DeclareTemplateCode,~
    each~choice~name~must~have~an~associated~implementation.\\
    This~should~be~given~after~a~'='~sign:~LaTeX~did~not~find~one.
  }
\msg_new:nnnn { template } { choice-requires-code }
  { The~choice~'#2'~for~key~'#1'~requires~an~implementation. }
  {
```

```
    You~should~have~put:\\
    \ \ #1~:~choice~{~#2 = <code> ~} \\
    but~LaTeX~did~not~find~any~<code>.
  }
\msg_new:nnnn { template } { duplicate-key-interface }
  { Key~'#1'~appears~twice~in~interface~definition~\msg_line_context:. }
  {
    Each~key~can~only~have~one~interface~declared~in~a~template.\\
    LaTeX~found~two~interfaces~for~'#1'.
  }
\msg_new:nnnn { template } { keytype-requires-argument }
  { The~key~type~'#1'~requires~an~argument~\msg_line_context:. }
  {
    You~should~have~put:\\
    \ \ <key-name>~:~#1~{~<argument>~} \\
    but~LaTeX~did~not~find~an~<argument>.
  }
\msg_new:nnnn { template } { invalid-keytype }
  { The~key~'#1'~is~missing~a~key-type~\msg_line_context:. }
  {
    Each~key~in~a~template~requires~a~key-type,~given~in~the~form:\\
    \ \ <key>~:~<key-type>\\
    LaTeX~could~not~find~a~<key-type>~in~your~input.
  }
\msg_new:nnnn { template } { key-no-value }
  { The~key~'#1'~has~no~value~\msg_line_context:. }
  {
    When~creating~an~instance~of~a~template~
    every~key~listed~must~include~a~value:\\
    \ \ <key>~=~<value>
  }
\msg_new:nnnn { template } { key-no-variable }
  { The~key~'#1'~requires~implementation~details~\msg_line_context:. }
  {
    When~creating~template~code~using~\DeclareTemplateCode,~
    each~key~name~must~have~an~associated~implementation.\\
    This~should~be~given~after~a~'='~sign:~LaTeX~did~not~find~one.
  }
\msg_new:nnnn { template } { key-not-implemented }
  { Key~'#1'~has~no~implementation~\msg_line_context:. }
  {
    The~definition~of~key~implementations~for~template~'#2'~
    of~template~type~'#3'~does~not~include~any~details~for~key~'#1'.\\
    The~key~was~declared~in~the~interface~definition,~
    and~so~an~implementation~is~required.
  }
\msg_new:nnnn { template } { missing-keytype }
  { The~key~'#1'~is~missing~a~key-type~\msg_line_context:. }
  {
    Key~interface~definitions~should~be~of~the~form\\
    \ \ #1~:~<key-type>\\
    but~LaTeX~could~not~find~a~<key-type>.
  }
\msg_new:nnnn { template } { no-template-code }
```

```
  {
    The~template~'#2'~of~type~'#1'~is~unknown~
    or~has~no~implementation.
  }
  {
    There~is~no~code~available~for~the~template~name~given.\\
    This~should~be~given~using~\DeclareTemplateCode.
  }
\msg_new:nnnn { template } { type-already-defined }
  { Template~type~'#1'~already~defined. }
  {
    You~have~used~\NewTemplateType~
    with~a~template~type~that~has~already~been~defined.
  }
\msg_new:nnnn { template } { type-mismatch }
  { Template~types~'#1'~and~'#2'~do~not~agree. }
  {
    You~are~trying~to~use~a~template~directly~with~\UseInstance
    (or~a~similar~function),~but~the~template~types~do~not~match.
  }
\msg_new:nnnn { template } { unknown-attribute }
  { The~template~attribute~'#1'~is~unknown. }
  {
    There~is~a~definition~in~the~current~template~reading\\
    \ \ \token_to_str:N \KeyValue {~#1~} \\
    but~there~is~no~key~called~'#1'.
  }
\msg_new:nnnn { template } { unknown-choice }
  { The~choice~'#2'~was~not~declared~for~key~'#1'. }
  {
    The~key~'#1'~takes~a~fixed~list~of~choices~
    and~this~list~does~not~include~'#2'.
  }
\msg_new:nnnn { template } { unknown-default-choice }
  { The~default~choice~'#2'~was~not~declared~for~key~'#1'. }
  {
    The~key~'#1'~takes~a~fixed~list~of~choices~
    and~this~list~does~not~include~'#2'.
  }
\msg_new:nnnn { template } { unknown-expansion }
  { The~expansion~type~'#1'~is~unknown. }
  {
    Key~values~can~only~be~expanded~using~one~of~the~pre-defined~methods:~
    n,~o,~V,~v,~e,~N~or~c.
  }
\msg_new:nnnn { template } { unknown-instance }
  { The~instance~'#2'~of~type~'#1'~is~unknown. }
  {
    You~have~asked~to~use~an~instance~'#2',~
    but~this~has~not~been~created.
  }
\msg_new:nnnn { template } { unknown-key }
  { Unknown~template~key~'#1'. }
  {
```

```
    The~key~'#1'~was~not~declared~in~the~interface~
    for~the~current~template.
  }
\msg_new:nnnn { template } { unknown-keytype }
  { The~key-type~'#1'~is~unknown. }
  {
    Valid~key-types~are:\\
    --~boolean;\\
    --~choice;\\
    --~commalist;\\
    --~function;\\
    --~instance;\\
    --~integer;\\
    --~length;\\
    --~muskip;\\
    --~real;\\
    --~skip;\\
    --~tokenlist.
  }
\msg_new:nnnn { template } { unknown-type }
  { The~template~type~'#1'~is~unknown. }
  {
    A~template~type~needs~to~be~defined~with~\NewTemplateType
    prior~to~using~it.
  }
\msg_new:nnnn { template } { unknown-template }
  { The~template~'#2'~of~type~'#1'~is~unknown. }
  {
    No~interface~has~been~declared~for~a~template~
    '#2'~of~template~type~'#1'.
  }
```

Information messages only have text: more text should not be needed.

```
\msg_new:nnn { template } { declare-instance }
  { Declaring~instance~~'#1'~of~type~#2~\msg_line_context:. }
\msg_new:nnn { template } { declare-template-code }
  { Declaring~code~for~template~'#2'~of~template~type~'#1'~\msg_line_context:. }
\msg_new:nnn { template } { declare-template-interface }
  {
    Declaring~interface~for~template~'#2'~of~template~type~'#1'~
    \msg_line_context:.
  }
\msg_new:nnn { template } { declare-type }
  { Declaring~template~type~'#1'~taking~#2~argument(s)~\msg_line_context:. }
\msg_new:nnn { template } { show-attribute }
  {
    The~template~'#2'~of~type~'#1'~has~
    \tl_if_empty:nTF {#4} { no~#3. } { #3 : #4 }
  }
\msg_new:nnn { template } { show-values }
  {
    The~instance~'#2'~of~type~'#1'~has~
    \tl_if_empty:nTF {#3} { no~values. } { values: #3 }
  }
```

Also add template to the LaTeX messages.

```
\prop_gput:Nnn \g_msg_module_type_prop { template } { LaTeX }
```

11.15 User functions

\NewTemplateType
\DeclareTemplateInterface
\DeclareTemplateCode
\DeclareTemplateCopy
\EditTemplateDefaults
\UseTemplate
\DeclareInstance
\DeclareInstanceCopy
\EditInstance
\UseInstance

All simple translations.

```
\cs_new_protected:Npn \NewTemplateType #1#2
  { \__template_define_type:nn {#1} {#2} }
\cs_new_protected:Npn \DeclareTemplateInterface #1#2#3#4
  { \__template_declare_template_keys:nnnn {#1} {#2} {#3} {#4} }
\cs_new_protected:Npn \DeclareTemplateCode #1#2#3#4#5
  { \__template_declare_template_code:nnnnn {#1} {#2} {#3} {#4} {#5} }
\cs_new_protected:Npn \DeclareTemplateCopy #1#2#3
  { \__template_template_set_eq:nnn {#1} {#2} {#3} }
\cs_new_protected:Npn \EditTemplateDefaults #1#2#3
  { \__template_edit_defaults:nnn {#1} {#2} {#3} }
\cs_new_protected:Npn \UseTemplate #1#2#3
  { \__template_use_template:nnn {#1} {#2} {#3} }
\cs_new_protected:Npn \DeclareInstance #1#2#3#4
  { \__template_declare_instance:nnnn {#1} {#3} {#2} {#4} }
\cs_new_protected:Npn \DeclareInstanceCopy #1#2#3
  { \__template_instance_set_eq:nnn {#1} {#2} {#3} }
\cs_new_protected:Npn \EditInstance #1#2#3
  { \__template_edit_instance:nnn {#1} {#2} {#3} }
\cs_new_protected:Npn \UseInstance #1#2
  { \__template_use_instance:nn {#1} {#2} }
```

(*End of definition for* `\NewTemplateType` *and others. These functions are documented on page* 3.)

\ShowTemplateCode
\ShowTemplateDefaults
\ShowTemplateInterface
\ShowTemplateVariables
\ShowInstanceValues

The show functions are again just translation.

```
\cs_new_protected:Npn \ShowTemplateCode #1#2
  { \__template_show_code:nn {#1} {#2} }
\cs_new_protected:Npn \ShowTemplateDefaults #1#2
  { \__template_show_defaults:nn {#1} {#2} }
\cs_new_protected:Npn \ShowTemplateInterface #1#2
  { \__template_show_keytypes:nn {#1} {#2} }
\cs_new_protected:Npn \ShowTemplateVariables #1#2
  { \__template_show_vars:nn {#1} {#2} }
\cs_new_protected:Npn \ShowInstanceValues #1#2
  { \__template_show_values:nn {#1} {#2} }
```

(*End of definition for* `\ShowTemplateCode` *and others. These functions are documented on page* 10.)

\IfInstanceExistsT
\IfInstanceExistsF
\IfInstanceExistsTF

More direct translation.

```
\cs_new:Npn \IfInstanceExistsTF #1#2
  { \__template_if_instance_exist:nnTF {#1} {#2} }
\cs_new:Npn \IfInstanceExistsT #1#2
  { \__template_if_instance_exist:nnT {#1} {#2} }
\cs_new:Npn \IfInstanceExistsF #1#2
  { \__template_if_instance_exist:nnF {#1} {#2} }
```

(*End of definition for* `\IfInstanceExistsT`, `\IfInstanceExistsF`, *and* `\IfInstanceExistsTF`. *These functions are documented on page* 8.)

\KeyValue Simply dump the argument when executed: this should not happen.

```
\cs_new_protected:Npn \KeyValue #1 {#1}
```

(*End of definition for* `\KeyValue`. *This function is documented on page* 4.)

\AssignTemplateKeys A short call to use a token register by proxy.

```
\cs_new_protected:Npn \AssignTemplateKeys { \__template_assignments_pop: }
```

(*End of definition for* `\AssignTemplateKeys`. *This function is documented on page* 5.)

\SetKnownTemplateKeys
\SetTemplateKeys A friendly wrapper, with some speed up for the common case of the third argument being empty.

```
\cs_new_protected:Npn \SetKnownTemplateKeys #1#2#3
  {
    \tl_if_empty:oTF {#3}
      {
        \tl_set_eq:NN  \UnusedTemplateKeys \c_empty_tl
      }
      {
        \keys_set_known:noN { template / #1 / #2 } {#3} \UnusedTemplateKeys
      }
  }
\cs_new_protected:Npn \SetTemplateKeys #1#2#3
  {
    \tl_if_empty:oF {#3}
      {
        \keys_set:no { template / #1 / #2 } {#3}
      }
  }
\tl_new:N \UnusedTemplateKeys
```

(*End of definition for* `\SetKnownTemplateKeys` *and* `\SetTemplateKeys`. *These functions are documented on page* 6.)

```
⟨latexrelease⟩\IncludeInRelease{0000/00/00}{lttemplates}%
⟨latexrelease⟩                  {Prototype~document~commands}%
⟨latexrelease⟩
⟨latexrelease⟩\EndModuleRelease
\ExplSyntaxOff
⟨/2ekernel | latexrelease⟩
```

We need to stop DocStrip treating `@@` in a special way at this point.

```
⟨@@=⟩
```

Index

The italic numbers denote the pages where the corresponding entry is described, numbers underlined point to the definition, all others indicate the places where it is used.

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